Study of the fast calorimeter prototype for modern e⁺e⁻ factories
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1. Introduction

Modern e⁺e⁻ factories with high luminosity require fast response time of the detector subsystems to suppress severe beam background. Calorimeter is one of the important subsystems of the detector.

Tasks of the calorimeter
- detects γ with high efficiency and good energy and time resolution
- monitor and measure luminosity
- generates signal for trigger of the detector
- provide particle identification
- suppress pileup noise.

Using fast scintillating crystals for calorimeter allows one to provide good energy and response resolution and to suppress pileup noise.

2. Basic components

**CsI crystal**
- Crystal
- T, ns
- Price, $/cm²
- CsI(Tl) 1000 50000 3
- CsI(pure) 30/1000 5000 5
- LuAlO₃ 18 20500 15-30
- LuAl₂O₇ 60 5600 15-30
- LuSiO₃ 12/2000 26000 15-30

Wavelength Shifting Plate
- The wavelength of the light, emitted by CsI(pure) crystal is 320 nm. Photo sensitivity of the APD is low for that wavelength.

Optimization of light collection
- Several types of optical epoxy resin to couple APDs to the side edges of the PMMA plate were studied with CsI(Tl) crystal and PMMA plate without NOL-9.

<table>
<thead>
<tr>
<th>resin/grease</th>
<th>cosmic peak position</th>
</tr>
</thead>
<tbody>
<tr>
<td>BC630 (grease)</td>
<td>1068 ± 14</td>
</tr>
<tr>
<td>BC630 (resin)</td>
<td>1444 ± 17</td>
</tr>
<tr>
<td>BC606 (resin)</td>
<td>923 ± 11</td>
</tr>
<tr>
<td>Polytec (resin)</td>
<td>1159 ± 15</td>
</tr>
</tbody>
</table>

NOL-9 allows one to improve APD photosensitivity by a factor of 3.

3. Components preparation

- PMMA plates of different shapes were tested with CsI(Tl) crystal and plate without NOL-9.
- 16 PMMA plates with shape 4 and NOL-9 were made. Also, one plate with shape 2 and NOL-34 was made. APDs were sorted and coupled with plates by BC-600. All these plates were used in a standard counter with CsI(pure) crystal and custom made preamplifier.

- 4-channel charge sensitive preamplifier 53 x 55mm² was developed for counter.
- Each channel: sensitivity of 0.2 V/pC, 2 input FET 2SK932 (high transconductance), differential output, HV bias circuit, test pulse input
- 16 custom charge sensitive preamplifiers were produced. Electronic noise factor of each preamplifier was measured.

4. Prototype

All plates, APDs, preamplifiers and crystals were sorted. 16 counters were assembled from relevant components. Light output and electronic noises of all counters were measured.

- In June 2019 we performed test beam studies with 1 fully assembled CsI(pure) counter with NOL-9 covered plate of shape 2.
- Electron beam with the energies 0.8, 1.5, 2.0, 2.5 and 3.0 GeV hit the center of the pure CsI crystal. Signals from the counter were recorded with the trigger from the external plastic scintillation detector and from CsI counter itself.
- In total about 1.2M events were recorded, got expected energy deposition spectra from the counter.

5. Summary

- CsI(pure) is an appropriate crystal for the fast calorimeter.
- All component’s characteristics were studied.
- Scheme of temperature compensation has been developed and now it is under testing.
- Testing of the prototype on registration of cosmic particles is under process.
- The prototype made of 16 counters will be studied soon on the test beam facility at VEPP-4M.